Attorney's Docket No. 024444-938

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of	
John Coogan et al.	Group Art Unit: 3721
Application No.: 09/857,688	Examiner: Thanh K. Truong
Filed: October 3, 2001	Appeal No.:
For: METHOD FOR CORRECTING POSTIONING ERRORS IN ROCK DRILLING, AND A ROCK DRILLING EQUIPMENT	

APPEAL BRIEF

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Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This appeal is from the decision of the Primary Examiner dated December 9, 2004 (Paper No. 12012004, finally rejecting claims 15-24, 27-31 and 33-37, which are reproduced as the Claims Appendix of this brief.

☒ A check covering the ☐ $250.00 (2402) ☒ $500.00 (1402) Government fee is filed herewith.

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I. Real Party in Interest

The real party in interest is the assignee, Sandvik AB, a Swedish company, including its subsidiary Sandvik Tamrock (a Finnish company).

II. Related Appeals and Interferences

There are no related appeals or interferences which would have a bearing on the Board's decision in this appeal.

III. Status of Claims

Claims 15-24, 27-31, and 33-37 are pending and have been finally rejected. In a concurrently filed amendment, it has been requested that claim 36 be canceled, so claim 36 has been omitted from the appendix.

IV. Status of Amendments

A concurrently filed amendment request that claim 36 be canceled. It is assumed for purposes of this Appeal Brief that the amendment will be entered, in order to simplify the issues on appeal.

V. Summary of Claimed Subject Matter

A) Background

The mining of rock or minerals involves drilling holes at predetermined locations in order to, for example, loosen the rock, or provide bores in which explosives can be positioned. Shown below is one type of prior art mechanism used for drilling holes in rock, i.e., a machine comprising a carrier such as a vehicle 1 to which is mounted one end of a boom 4 for rotation relative to the carrier about one or more axes, e.g., vertical and horizontal axes defined by joints 3 and 2, respectively.

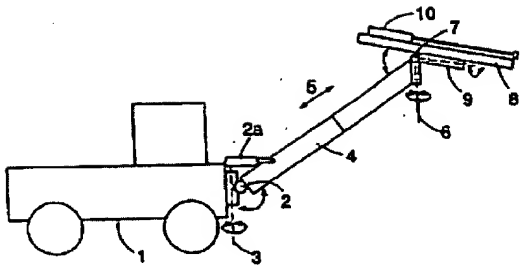
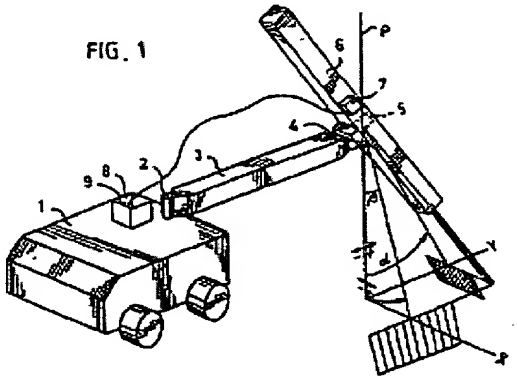


FIG. 1

Mounted at an opposite end of the boom is a feed beam 8, 9 on which is slidably mounted a rock drill 10. The feed beam 8, 9 is pivotable relative to the boom about vertical and horizontal axes defined respectively by joints 6 and 7. In order to properly position the rock drill 10 for a drilling operation, it is swung about one or more of the joints 2, 3, 6 and 7.

For economic reasons, it is desirable that the holes be drilled as precisely as possible at predetermined drilling locations. To accomplish that objective, automatic drilling boom positioning and controlling devices are used in order to correct for various positioning errors that can occur when moving a boom. For example, in Rinnemaa U.S. Patent No. 5,383,524 (Fig. 1 shown below), there is disclosed a mechanism which deals with inaccuracies that can occur when moving the feed beam 6 in multiple planes arranged perpendicularly to one another (e.g., X and Y planes).

FIG. 1



That is, Rinnemaa assumes that: (1) the incremental angles of movement of the beam 6 in each plane are *accurately sensed* by a respective gravity sensor, and that (2) if the beam 6 is moved simultaneously in more than one plane, then errors will occur in the gravity sensors due to principles of geometry, which errors are capable of being predetermined mathematically. Thus, Rinnemaa teaches to mathematically calculate the errors for various combinations of angular movements of a feed beam, e.g., an angle a in one plane plus an angle b in another plane, so that a compensation for the errors can be made during an actual drilling operation.

B) Present Invention

In contrast, the presently claimed invention seeks to compensate for deviations which result from mechanical causes relating to the boom (not the feed beam), e.g., loose play in the boom joints, deformations of various parts, etc., rather than on geometric principles. The present invention assumes that movements of a boom within a single plane may be *inaccurately sensed* due to those mechanical causes. Those deviations cannot be predetermined mathematically, so the invention involves actually moving the boom incrementally along its path of movement about one joint and determining the deviation occurring for each increment of movement (resulting from loose play, deformations, etc.) Thus, for example, one can determine the deviations that occur as the boom 4 is swung about joint 2, and store such deviations, so a correction can be made when such movement is subsequently performed during an actual drilling operation. In the same way, one can determine the deviations that occur during rotation of the boom about the axis 3, so another correction can be made if the device 9 is also rotated about axis 3 during a drilling operation.

Thus, the present invention involves turning the boom 14 through incremental angles about one of the axes of the joints 2, 3 from a reference position to predetermined angularly spaced intervals, and measuring (by means of a movement sensor), for each such interval, a deviation of the boom position from a desired incremental turning angle. There can thus be obtained a first set of deviations which are stored in a memory. During a subsequent drilling operation, that set of stored

deviations is used as correction values for locating the boom at the desired incremental turning angles corresponding to the respective predetermined angularly spaced intervals about that same joint axis (see the present description at page 5, lines 1-15 and page 6, lines 16-31).

VI. Issues

At issue is whether claims 15-24, 27-31, 33-35 and 37 are anticipated by Rinnemaa U.S. Patent No. 5,383,52.

It is being assumed that a prior issue as to whether claim 36 is indefinite will be obviated by the cancellation of claim 36 as requested in the concurrently filed amendment.

VII. Grouping of Claims

All claims rise or fall together.

VIII. Argument

The presently claimed invention relates to problems caused by deviations occurring during boom movement which cannot be theoretically (mathematically) calculated, e.g., deviations resulting from looseness of joints, deformations of parts. Conventional sensors used to sense boom movements are not sensitive to such deviations, so data received from the sensors may not be accurate. To deal with that problem, the present invention involves actually moving the boom incrementally through the various angles about a joint and measuring the deviation of the actual boom position from a desired angle after each incremental movement. During an actual drilling operation, when the boom is intended to be moved by a desired angle, the stored deviation data can be used to impart a movement to the boom to compensate for the looseness of joints, deformation of parts, etc.

For example, method claim 15 recites, in step A, storing deviations obtained by turning the boom through incremental during angles about a joint axis and measuring

a deviation from a desired turning angle. Step B recites using the stored deviations during a subsequent drilling operation as correction values.

Apparatus claim 19 recites a memory device for storing deviations obtained by turning the boom through incremental angels, and measuring the deviations, and a calculating device operable during a drilling operation for using the stored deviations as correction values.

Method claim 23 also recites, in the last two paragraphs thereof, the steps of storing deviations obtained by turning the boom and measuring the deviations, and using the stored deviations to correct the drilling position of the boom.

Apparatus claim 34 recites a memory device for storing deviations obtained by turning the boom through various positions, measuring deviations, and a calculating device operable during a drilling operation, for using the stored deviations as correction values.

As explained earlier, the Rinnemaa invention involves a rock drill and deals with inaccuracies or deviations that may occur when moving a feeding beam 6 of the rock drill to a desired position (the feeding beam 6 being mounted on the boom 3). Rinnemaa points that when the beam 6 in Fig. 1 is inclined from a reference position in only one plane, a sensor 7 can accurately measure the angle of inclination.[1] However, when the beam is inclined from the reference position in two planes, the sensor accuracy is diminished for reasons of geometry (not for reasons caused by loose joints or deformation of parts). In particular, with reference to column 5, lines 23-34 of the patent:

> When the feeding beam is inclined solely in the direction of one measuring plane, such as the y plane, the sensor of this plane indicates accurately the inclination of the feeding beam. When the feeding beam is additionally turned in the direction of the x plane, the sensor 7y gives a greater angle value even though the angle actually remains unchanged in the direction of the y plane. As a consequence, when calculating the actual direction of the feeding beam, the influence of the inclination in the direction of the other plane has to be taken into account in order to avoid erroneous drilling direction. (emphasis added)

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[1] That assumes that there are no deviations resulting from mechanical causes (loose play in the joints, deformation of parts) of the type corrected by the presently claimed invention.

To deal with that problem, Rinnemaa takes advantage of the fact that since the errors or deviations are based upon geometry, it is possible to "calculate" the deviation once the values of the angles are supplied by the angle sensors. In other words, Rinnemaa never measures actual deviations, he calculates them on the basis of knowing the values of the angular turns that the beam is to undergo.

> This is achieved by means of a method according to the invention in such a way that the angle value indicated by the sensor is corrected by calculation in such a way that it corresponds to the actual angle of inclination of the feeding beam by allowing for the influence of an error caused by the inclination feeding beam in the other measuring plane at an angle with respect to the measuring plane of the sensor, and that the feeding beam is aligned in a predetermined direction on the basis of the angle value of the sensor after the value has been corrected by calculations so that it corresponds to the actual angle of inclination." (Rinnemaa, column 2, line 62 to column 3, line 5) (emphasis added)

While that solution may serve to compensate for geometric deviations, it does not compensate for deviations resulting from deformations of parts, or looseness between parts, etc.

The present invention compensates for all sources of deviations because the invention involves measuring the deviations themselves. That is, the boom is moved from position to position incrementally, so that numerous deviations of the actual position from the expected position can be measured. That takes into account all sources of the deviation.

In the Final Rejection, the following assertion was made regarding Rinnemaa:

> "The deviation of the boom position from the theoretical position is measured at predetermined intervals (inherently discloses) as a function of position of boom joint, and the position is corrected on the basis of the stored deviation... (column 2, lines 62-68 and column 3, lines 1-5)" (Final rejection, page 3, second paragraph)

However, nowhere in that cited passage from Rinnemaa is it disclosed to measure a deviation. In column 2, lines 62-68, it is disclosed to take the angle values provided by the angle sensors and then correct them "by calculation".

Also, nowhere in that cited passage is there a disclosure of storing deviations. Calculations are made, but no deviations are measured or stored.

Moreover, those cited recitations relate to the position of the feeding beam; the boom is not mentioned.

The Final Rejection also asserts as follows:

> "Rinnemaa also discloses that the deviation values [are] collected and stored in a memory" (column 6, lines 54-59)." (Final rejection, page 3 last full paragraph)

That part of the patent's description relates to the situation where an inclination of the mobile carrier 1 must be taken into account. That is done by storing the carrier's inclination into a memory and has nothing to do with the storing of boom deviations as in the presently claimed invention. Rinnemaa states:

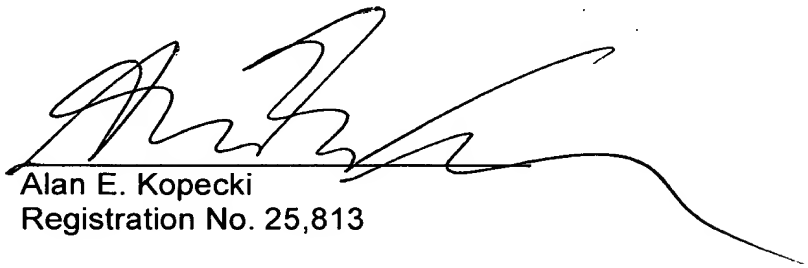
> When the boom and the feeding beam are in these fixed positions, the inclination of the carrier can be obtained direction from the inclination sensors of the feeding beam in the longitudinal and transverse planes of the carrier, whereby these values can be set in the memory of the calculator unit, and the correction calculations needed in the positioning of the feeding beam and the boom can then be made on the basis of the inclination values of the carrier set in the memory as long as the carrier is not displaced." (column 7, lines 50-59) (emphasis added)

In light of the foregoing comments, it is submitted that the rejection of independent claims 15, 19, 23 and 34 should be reversed.

Respectfully submitted,

BUCHANAN INGERSOLL PC

Date: November 14, 2005

By: 

Alan E. Kopecki
Registration No. 25,813

P.O. Box 1404
Alexandria, Virginia 22313-1404
(703) 836-6620

Table of Contents

VIII. CLAIMS APPENDIX

The Appealed Claims

15. A method for correcting positioning errors in rock drilling occurring in a drilling rig comprising a boom and a rock drill, the boom attached at one end thereof to a carrier and being turnable in relation to it about one or more joint axes of one or more respective joints, the rock drill being turnably mounted to another end of the boom, the apparatus arranged in a drilling position for drilling a hole in a way that the boom is controlled using control devices of the drilling rig wherein the boom is subjected to various movements until the boom is in a desired set position, wherein a deviation of the boom's actual turning angle about one of said joint axes from a desired turning angle about said one of said joint axes is measured using a movement sensor, and the boom's position is corrected on the basis of the measured deviation, the method comprising the steps of:

A) storing, in a memory, a first set of deviations obtained by turning the boom through incremental turning angles about said one of said joint axes from a reference position to predetermined angularly spaced intervals about said one of said joint axes, and measuring using a movement sensor, for each such interval, a deviation of the boom position from a desired incremental turning angle, and

B) using the stored first set of deviations during a subsequent drilling operation as correction values for locating the boom at the desired incremental turning angles corresponding to the respective predetermined angularly spaced intervals about said one of said joint axes.

16. The method according to claim 15 wherein step A further comprises storing a second set of deviations obtained independently of the first set of deviations by turning the boom through incremental turning angles about a second one of said one or more joint axes of one or more respective joints from a reference position to predetermined angularly spaced intervals about said second one of said one or more joint axes and measuring using a movement sensor, for each such interval, a deviation of the boom position from a desired incremental turning angle; step B comprising using the stored second set of deviations during the drilling operation as correction values for locating the boom at the desired incremental turning angles corresponding to the respective predetermined angularly spaced intervals about said second one of said one or more joint axes.

17. The method according to claim 15 wherein an outer section of the boom is linearly extendable and retractable relative to an inner section thereof, step A further comprising storing another set of deviations obtained independently of the first set of deviations by moving the outer section from a reference position to linearly spaced intervals and measuring, for each linearly spaced interval, a deviation of the boom outer section from a desired position; step B comprising using the stored other set of deviations during the drilling operation as correction values to locate the boom in the desired positions corresponding to the linearly spaced intervals.

18. The method according to claim 15 wherein deviations occurring at a location between two of the angularly spaced intervals is determined by calculating an approximation based upon the measured deviations at the two angularly spaced intervals.

19. Rock drilling apparatus comprising a carrier, a boom having a first end attached to the carrier and turnable about respective joints in relation to the carrier, a rock drill attached turnable to the other end of the boom, joint sensors indicating the positions of the boom joints, and control devices for controlling the boom for movement to a drilling position for drilling a hole, the apparatus further comprising:

a memory device for storing a first set of deviations obtained by turning the boom through incremental turning angles about a first joint axis of the joints from a reference position to predetermined angularly spaced intervals about said first joint axis of the joints, and measuring using a movement sensor for each such interval a deviation of the boom position from a desired position, and

a calculating device operable during a drilling operation for using the stored first set of deviations as correction values for locating the boom in the desired positions corresponding to the respective intervals about the first joint axis.

20. The apparatus according to claim 19 wherein the memory device is operable to store a second set of deviations obtained independently of the first set of deviations by turning the boom through incremental turning angles about a second joint axis of said joints from a reference position to predetermined angularly spaced intervals about said second joint axis and measuring using a movement sensor, for each such interval, a deviation of the boom position from a desired position; the calculating device being operable to use the stored second set of deviations during

the drilling operation as correction values for locating the boom in the desired positions corresponding to the respective intervals about the second joint axis.

21. The apparatus according to claim 19 wherein an outer section of the boom is linearly extendable and retractable relative to the inner section thereof, the memory device being operable to store another set of deviations obtained independently of the first set of deviations by moving the outer section from a reference position to linearly spaced intervals and measuring, for each linearly spaced interval, a deviation of the boom outer section from a desired position; the calculating device being operable to use the stored other set of deviations during the drilling operation as correction values to locate the boom in the desired positions corresponding to the linearly spaced intervals.

22. The apparatus according to claim 19 wherein the first joint axis is parallel to a rotary axis of the rock drill.

23. A method for correcting positioning errors in a rock drilling rig, the rock drilling rig comprising:

a boom attached at one end to a carrier and being rotatable in relation to the carrier about a plurality of joints;

a rock drill being turnably mounted to the other end of the boom; and

control devices for controlling the boom through various positions until the boom is set in a drilling position for drilling a hole;

wherein a deviation of the boom's drilling position is measured from a calculated theoretical position of where the boom should be located for drilling, and the boom's drilling position is corrected on the basis of the measured deviation, the method comprising the steps of:

storing in memory, a set of deviations obtained by turning the boom through the various positions and measuring, at predetermined angular intervals about at least one joint, the deviation of the boom's position from a calculated theoretical position at each interval, and

using the set of stored deviations to correct the drilling position of the boom relative to the at least one joint.

24. The method according to claim 23, wherein the deviation of the boom position from the calculated theoretical position at each interval is measured in the turning direction of at least one joint between the boom and the carrier.

27. The method as claimed in claim 23, wherein the method is employed for rotations about each of the plurality of joints, such that a set of deviations and an error compensation function are provided for boom movements relating to each of the plurality of joints.

28. The method according to claim 23, wherein the deviations corresponding to each joint position are measured at predefined angular intervals in a certain joint position value and, when positioning the boom to the drilling position, the calculated theoretical position of the boom is corrected on the basis of the deviations corresponding to the joint positions obtained in this way.

29. The method according to claim 28, wherein the deviation between adjacent, stored joint positions of each turning movement is defined by calculating an approximation for the change of deviation from one position value to the other on the basis of the measured deviations between the said joint position values.

30. The method according to claim 29, wherein the approximation for the deviation is calculated between the deviation values stored in a memory.

31. The method according to claim 23, wherein deviation caused by at least one other movement is measured as a function of the value of a movement sensor, and the theoretical position of the boom is corrected on the basis of the deviation corresponding additionally to this movement when positioning the boom to the drilling position.

33. The method according to claim 23, wherein the deviations are stored as deviations of the drill bit position of the rock drill and deviations of the drilling direction determined by the drill steel axis.

34. A rock drilling equipment, with a carrier, a boom having a first end attached to the carrier and turnable about respective joints in relation to the carrier, a rock drill turnably attached to the other end of the boom, joint sensors indicating the positions of the boom joints, and control devices for controlling the boom through various positions to reach the drilling position for drilling a hole, characterized in that it includes a memory device for storing a set of deviations obtained by turning the boom through the various positions and measuring, at predetermined angular intervals, about at least one joint, the deviation of the boom's position from a calculated theoretical position at each interval, and a calculating device operable during a drilling operation for using the stored set of deviations as correction values for correcting the drilling position of the boom relative to the at least one joint.

35. The rock drilling equipment according to claim 34, wherein the memory device is arranged to store the deviations between the position of the boom and the theoretical value calculated at each interval on the basis of the joint sensors as a function of the turning angles of two to one another crossing joints between the boom and the carrier, and the calculating device is arranged to correct the boom position on the basis of the deviations, stored in the said memory unit, corresponding to the position and indicated by the joint sensors of both joints.

36. The rock drilling equipment according to claim 35, wherein the memory device is arranged to store the deviations in a two-dimensional coordinate system between the position of the boom and the theoretical position calculated at each interval on the basis of the joint sensors as a function of the positions of two crossing joints.

37. The rock drilling equipment according to claim 34, equipped with a separate rotating mechanism for rotating the rock drill in relation to the boom end and about an axis that is parallel with the drilling axis of the rock drill, wherein the memory device is arranged to store the deviations between the position of the boom and the theoretical position calculated at each interval on the basis of the joint sensors, as a function of the position of the rotation mechanism, and the calculating device is arranged to correct the boom position and the turning angles of the joints between the boom and the carrier and correspondingly the turning angle of the rotating mechanism on the basis of the corresponding deviations.